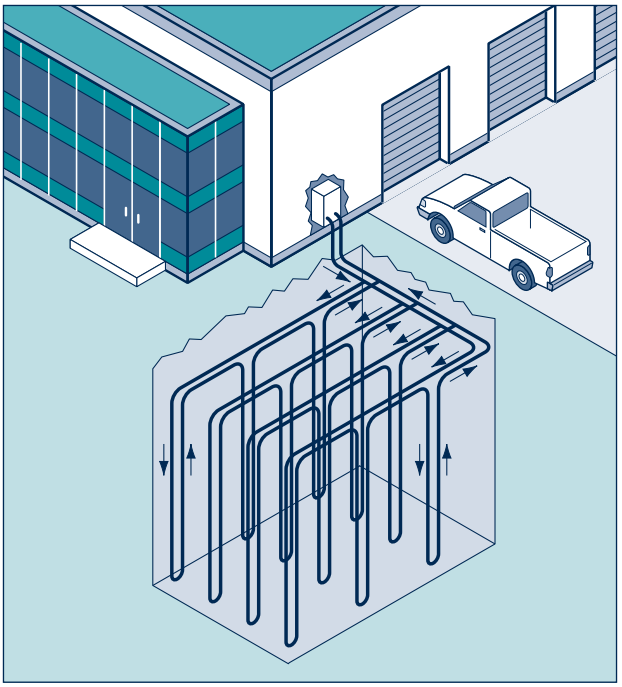
Geothermal Heat Pumps for Medium and Large Buildings

Business owners around the United States are installing geothermal heat pumps to heat and cool their buildings. This well-established technology offers benefits to businesses that range from increased comfort for employees and customers to significant dollar savings in energy and operation and maintenance costs.

Geothermal heat pumps (GHPs) are also known as ground source or water source heat pumps and GeoExchange℠ systems. They use the relatively constant temperatures—typically 45°F to 70°F (7°C to 21°C)—of soil and water beneath the frost line to provide efficient heating and cooling all year long. The efficiencies achieved by these systems are impressive and allow commercial users to save up to 50 percent over conventional heating and cooling systems, plus they reduce maintenance costs.

The environment also benefits when business owners choose geothermal heat pumps. The U.S. Department of Energy's (DOE) Geothermal Heat Pump Program has set a goal of two million units installed by the year 2005. Achieving this objective will save consumers about $400 million per year in energy bills and reduce U.S. greenhouse gas emissions by over 1 million metric tons of carbon each year.



Geothermal heat pumps use the stable temperature of the ground (vertical boreholes are typically 100 to 400 feet deep) as a heat source to warm buildings in winter and as a heat sink to cool them in summer.

Business people who own these systems swear by them. According to Marion Pinckley, designer and construction manager for the world's largest GHP system, their enthusiasm is well founded. "The initial cost of a GHP system is often competitive with conventional HVAC equipment, and the operation and maintenance costs are usually much lower, typically yielding a simple payback of five years or less," explains Pinckley. "In

Jeff Frey, Photographer/PIX06542

The GHP system in this Minnesota gas station heats and cools the building; provides hot water, food refrigeration, and ice making; and melts snow to and from the car wash.

Minnesota GHP System Pays Off

Marvin Hansen's "Skunk Creek" Conoco station (shown at left) in Sandstone, Minnesota, is the first integrated GHP system in Minnesota. Hansen chose the system based on a recommendation from Duluth-based utility Minnesota Power, which provided technical and project management assistance and helped defray the cost of the mechanical design. According to Minnesota Power's Randy Richgruber, the utility estimates that the system saves Hansen $5,000 each year compared with a conventional furnace and water heater, with a payback of less than five years.

addition, every room in the building can have its own comfort control. In my 45 years in the business, I've worked with nearly every HVAC system available, and you can't beat GHP systems for economy, comfort, flexibility, and environmental benefits."

Improving the Bottom Line

Business owners and managers like to save money, and that's one of the things a well-designed GHP system does best by reducing monthly energy bills. But GHPs also have less obvious economies. These units can heat water for free in the summer with rejected waste heat from air conditioning. Reclaimed waste heat from freezers and ice machines can also be used for space or water heating and snow-melting systems. For example, at Marvin Hansen's "Skunk Creek" Conoco station in Sandstone, Minnesota, the heat rejected by the store refrigeration equipment and GHP—which would be wasted in a conventional system—is transferred to the ground loop where it is used by two water-to-water GHPs to heat domestic water and water for the car wash. During the winter, this recycled heat warms the concrete slab floor in the car wash and provides heat for the entrance and exit ramp snow melting system. The result is that heat is never wasted, but rather it is moved to where it can be used or "stored" in the earth connection for later use.

Because these systems have fewer mechanical components, they are also more reliable, easier to service, and less prone to failure. It is not uncommon to find geothermal systems that were installed 30 or 40 years ago still operating effectively today. The results of these combined efficiencies include dollar savings for the building owner and avoided air and water pollution.

In large buildings, many individual heat pumps can be placed in different zones and each can be sized to meet the needs of the space it conditions. When properly integrated, these systems recover excess heat from one indoor zone of the building and use it where it is needed. For example, heat pumps on the sunny side of a large building with an integrated system can provide cooling while those on the shady side are providing heat. Each of these individual units is attached to the same earth connection by a loop inside the building. It is even possible to connect multiple buildings in the same general area to the same earth connection.

If one of the heat pumps in a multi-pump installation does need servicing or replacement, the problem is easily isolated and corrected because of the modular nature of the equipment. The rest of the heating and cooling system is not affected.

GHPs also save money in large buildings with multiple heat pumps by reducing the amount of space required for mechanical rooms. GHP systems use smaller ducts, because the air handling system only provides make-up air and does not carry heat. This results in smaller floor-to-floor heights as heating and cooling BTUs are transferred via small pipes rather than bulky ducting. By eliminating roof-mounted equipment, the roof lasts longer and the structural steel can be downsized.

In large commercial installations, the initial costs of GHPs are very competitive with boilers and cooling towers. Major projects (larger than 300 tons) often attract bidders from all over the country for designing, drilling, and installation, thereby achieving very competitive prices.

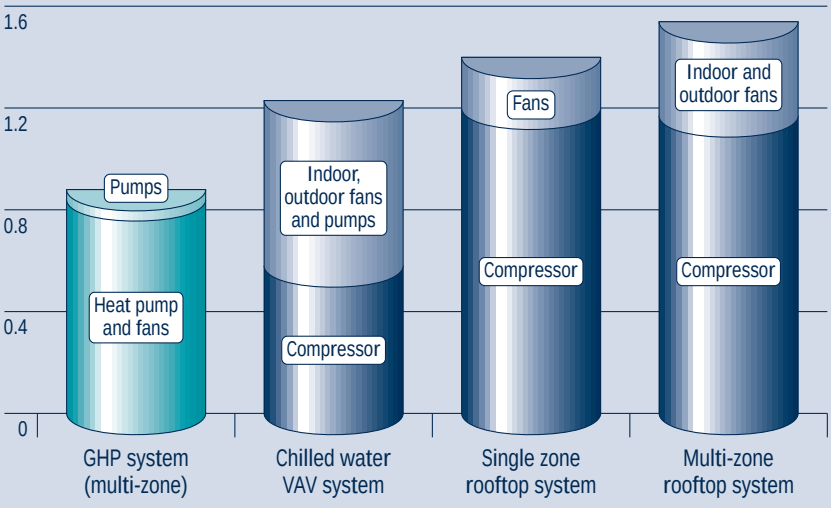
Opportunity for Energy Service Companies

Why should an energy service company (ESCO) offer GHPs? Because they are a much better investment than conventional systems! A 1997 analysis shows that conventional heating and air-conditioning in a base case office building installed under an energy service pricing contract earns an internal rate of return (IRR) of 9%. Under the same circumstances, GHPs provide an IRR of at least 28% for contract periods up to 20 years—while still reducing equivalent customer bills by 5%. If the ESCO can integrate the HVAC design into the building plan early in the design process, the rate of return can be even better.

This comparison was developed with computer models using actual GHP operating data. Barakat and Chamberlin, Inc., defines the benefits of GHPs as "ideally suited to energy service pricing contractual arrangements."

Source: Barakat and Chamberlin, Inc., "Geothermal Heat Pump Profitability in Energy Services," November 1997.

Comparison Between GHP and Conventional Systems: Electricity Used



All these economies add up to a handsome return on investment for businesses that choose GHPs. If the initial cost of installing a GHP system is higher, these systems typically pay for themselves in reduced energy and maintenance costs in less than five years.

Roadmap for Success

The benefits of GHPs can be tailored to many specific businesses, such as gas stations, motels, hotels, retirement centers, large and small office buildings, auto maintenance facilities, and others.

In some places, local utilities offer design assistance, referrals, or financial incentives to offset the initial cost of purchasing and installing them. The Geothermal Heat Pump Consortium (GHPC) also offers some design assistance (see *For More Information*). In addition, many energy service companies (ESCOs)—businesses that install energy-saving technologies and whose fees are paid out of the subsequent energy savings—offer GHPs to their clients.

How a GHP System Works

GHPs are far more versatile than conventional HVAC systems, because they provide space conditioning—heating, cooling, humidity control—and many installations also provide hot water. GHPs do not require a boiler or cooling tower, which makes them simpler than conventional HVAC systems to operate and maintain.

GHPs exchange heat with the earth through a system of buried plastic pipes called a ground heat exchanger. In the winter, fluid in the pipes extracts heat from the earth and carries it through the system and into the building. In the summer, heat is pulled from the building, carried through the system, and deposited in the cool earth. GHPs located inside the building distribute the warmed or cooled air throughout the interior.

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This commercial-sized GHP unit, installed in Cavett Elementary School, Lincoln, Nebraska, provides reliable year-round comfort.

In commercial installations, an underground heat exchanger and a fluid-pumping or circulation system are combined with packaged geothermal heat pumps. The heat pumps are placed throughout the building to provide multiple temperature-controlled comfort zones. GHPs can be configured for single rooms or zones with individual circulating pumps and ground heat exchangers. In large installations, the system consists of a ground heat exchanger with a single pumping station serving multiple heat pump units.

Comfort and Security

In addition to saving money, GHPs provide very comfortable heating and cooling. Customer satisfaction ranks among the highest of all heating and cooling systems. Building owners and users can simultaneously heat and cool, provide many separate comfort zones, heat and cool selectively, and operate with very little down time.

The equipment used in GHPs is either underground or located indoors so it is not vulnerable to vandalism or mechanical failures caused by severe weather. The GHPs are very quiet, which makes it possible to install them anywhere in the building—in closets, above suspended ceilings, or as self-contained consoles. Typically, GHPs do not require roof-top units, which are undesirable aesthetically and require roof penetrations, with the potential for leaks and future maintenance.

Good News for the Environment

Consumers are becoming more sophisticated about patronizing businesses that demonstrate sensitivity to the environment, and they consistently rank their comfort and satisfaction with GHPs higher than with any other system. Combine this with the fact that the higher initial investment is repaid quickly through lower energy and maintenance bills, and it is easy to see why GHPs are becoming a popular HVAC choice among knowledgeable business people.

DOE Involvement

In 1994, the U.S. Department of Energy (DOE), working closely with the EPA, Edison Electric Institute, Electric Power Research Institute, International Ground Source Heat Pump Association (IGSHPA), National Rural Electric Cooperative Association, and industry, helped to form the Geothermal Heat Pump Consortium (GHPC). The GHPC launched the National Earth Comfort Program, designed to foster the development of a fast-growing, self-sustaining, national GHP industry infrastructure. DOE has also supported research and development activities, especially through IGSHPA; the American Society of Heating, Refrigeration, and Air-Conditioning Engineers; the National Ground Water Association; and DOE's national laboratories. The work has targeted several areas of GHP technology, lowering the cost of ground heat exchangers, and developing advanced design software.

World's Largest GHP System


PIX06541

The Galt House East Hotel and Waterfront Office Buildings in Louisville, Kentucky, use a 4,700 ton GHP system to meet the heating and cooling needs of the complex. The 750,000-square-foot (70,000 m^2) Galt House East hotel, completed in 1984, uses a 1,700-ton GHP system, which cost $1,500 per ton to install. In comparison, a conventional system would have cost between $2,000 and $3,000 per ton. As a bonus, the system saves about $25,000 per month in reduced energy costs and frees up about 25,000 square feet (2,323 m^2) of additional commercial space that would have been needed to house conventional HVAC equipment. The Waterfront Office Buildings, built in 1994, add about 960,000 square feet (89,000 m^2) of office space and almost 3,000 tons of GHP capacity to the project, making this the world's largest commercial GHP project. According to Marion Pinckley, Galt House designer and construction manager, "Galt House East has been running for 15 years with no system problems. The GHP system has performed even better than expected."

For More Information

The following organizations serve as excellent resources for information on geothermal energy and its various applications.

U.S. Department of Energy (DOE)
Office of Geothermal Technologies, EE-12
1000 Independence Avenue, SW
Washington, DC 20585-0121
(202) 586-5340
http://www.eren.doe.gov/geothermal/

The Energy Efficiency and Renewable Energy Clearinghouse (EREC)
P.O. Box 3048
Merrifield, VA 22116
(800) DOE-EREC (363-3732)
Fax: (703) 893-0400
E-mail: doe.erec@nciinc.com
http://www.eren.doe.gov/consumerinfo

Geo-Heat Center
Oregon Institute of Technology
3201 Campus Drive
Klamath Falls, OR 97601-8801
(503) 885-1750
http://www.oit.osshe.edu/~geoheat/

Geothermal Heat Pump Consortium, Inc. (GHPC)
701 Pennsylvania Avenue, NW
Washington, DC 20004-2696
(888) ALL-4-GEO (255-4436)
http://www.geoexchange.org/

International Ground Source Heat Pump Association (IGSHPA)
490 Cordell South
Stillwater, OK 74078-8018
(405) 744-5175
(800) 626-4747
http://www.igshpa.okstate.edu/

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